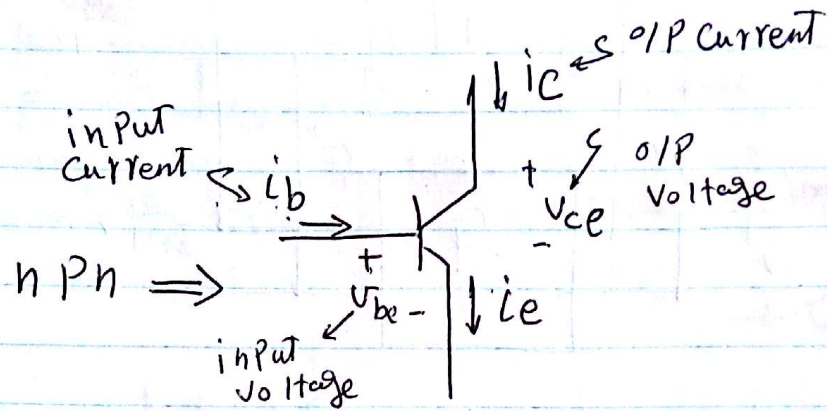


- application of the two network in small signal Transistor Amplifier



h-Parameter لا يتبدل في BJT بالترانزستور في
 على التتابع (amplifier) X جاد
 - عامل تكبير الجهد
 - " " التيار
 - " " Power

→ h-Parameter equation..

بالنسبة لـ BJT

$$\begin{aligned} V_1 &= h_{11} I_1 + h_{12} V_2 \\ I_2 &= h_{21} I_1 + h_{22} V_2 \\ \Rightarrow V_{be} &= h_{11} i_b + h_{12} v_{ce} \\ \Rightarrow i_c &= h_{21} i_b + h_{22} v_{ce} \end{aligned}$$

OR $V_{be} = h_{11} i_b + h_{12} v_{ce}$

$$\rightarrow h_{ie} = h_{11} = \frac{V_{be}}{I_b} \bigg|_{V_{ce}=0}$$

input impedance

$$\rightarrow h_{re} = h_{12} = \frac{V_{be}}{V_{ce}} \bigg|_{I_b=0}$$

reverse voltage gain

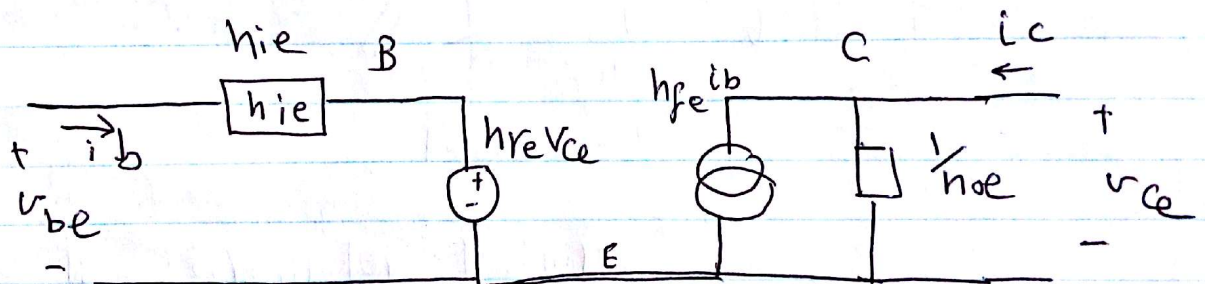
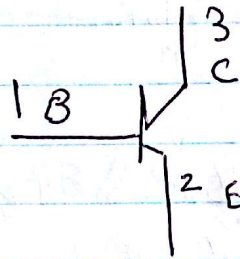
$$\rightarrow h_{fe} = h_{21} = \frac{I_c}{I_b} \bigg|_{V_{ce}=0}$$

Forward Current gain

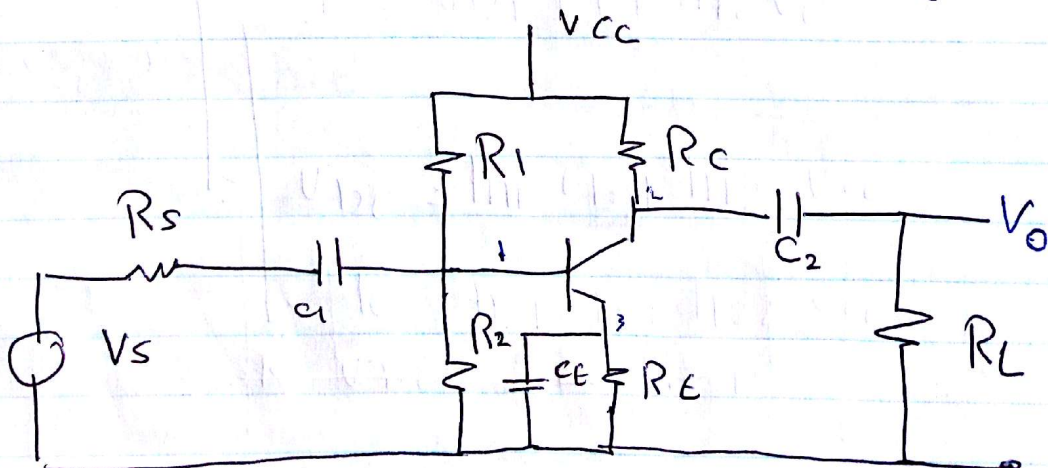
$$\rightarrow h_{oe} = h_{22} = \frac{I_c}{V_{ce}} \bigg|_{I_b=0}$$

output impedance

دائرة الارتفاع

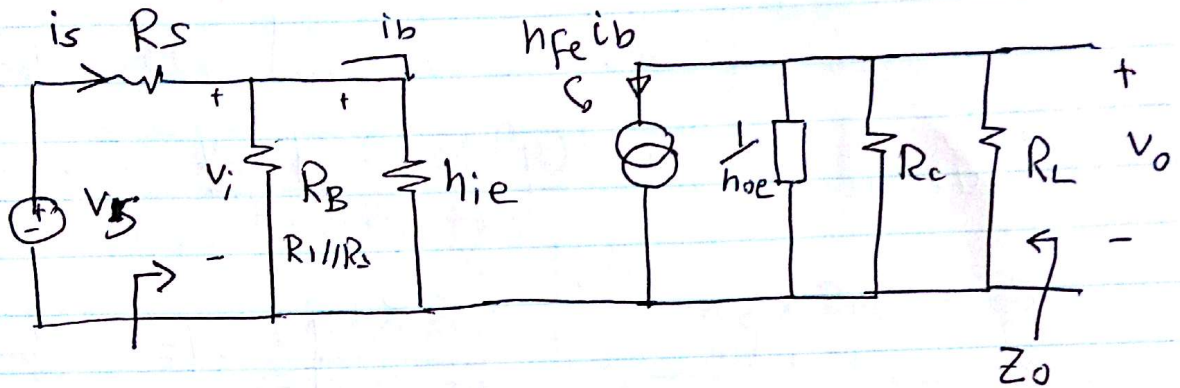


→ Find The voltage gain and Current gain for



في حالة تحليل الترانزستور في حالة التردد المنخفض. جميع المكثفات = تعتبر S.C

الدائرة المكافئة



$$Z_i = R_s + (R_B \parallel h_{ie})$$

$$Z_o = R_L \parallel R_c \parallel \frac{1}{h_{oe}}$$

* the voltage gain A_v

$$A_v = \frac{V_o}{V_i}$$

$$V_o = -h_{fe} i_b Z_o$$

$$V_i = i_b h_{ie} \Rightarrow i_b = \frac{V_i}{h_{ie}}$$

$$\therefore V_o = -h_{fe} \frac{V_i}{h_{ie}} Z_o$$

$$A_v = \frac{V_o}{V_i} = -h_{fe} \frac{Z_o}{h_{ie}}$$

overall voltage gain A_{v_s}

$$A_{v_s} = \frac{V_o}{V_s} = \frac{V_o}{V_i} * \frac{V_i}{V_s}$$

$$\frac{V_i}{V_s} = ??$$

$$V_i = \frac{V_s * (h_{ie} // R_B)}{(h_{ie} // R_B) + R_s}$$

$$\frac{V_i}{V_s} = \frac{(h_{ie} // R_B)}{(h_{ie} // R_B) + R_s} = \frac{\frac{h_{ie} * R_B}{h_{ie} + R_B}}{\left(\frac{h_{ie} * R_B}{h_{ie} + R_B}\right) + R_s}$$

$$\frac{V_i}{V_s} = \frac{h_{ie} * R_B}{h_{ie} * R_B + (h_{ie} + R_B) R_s}$$

$$\therefore A_{v_s} = \frac{V_o}{V_i} * \frac{V_i}{V_s} = A_v * \frac{h_{ie} R_B}{h_{ie} * R_B + h_{ie} R_s + R_s R_B}$$

$$A_{v_s} = A_v \frac{R_B h_{ie}}{R_B \left[h_{ie} + \frac{R_s}{R_B} h_{ie} + R_s \right]}$$

$$A_{v_s} = A_v \frac{h_{ie}}{R_s + \frac{R_s}{R_B} h_{ie} + h_{ie}} \quad \text{X}$$

- Current gain

$$A_i = \frac{i_o}{i_i} = \frac{i_L}{i_i} = -\frac{h_{fe} Z_o}{R_L}$$

$$V_o = i_o R_L,$$

$$i_o = \frac{V_o}{R_L}$$

$$i_{in} = \frac{V_{in}}{h_{ie}}$$

$$\text{then } \frac{i_o}{i_{in}} = \frac{V_o}{V_{in}} \frac{h_{ie}}{R_o} = \boxed{A_v \frac{h_{ie}}{R_L}}$$

- Total ~~current~~ current gain:

$$A_{i_s} = \frac{i_o}{i_s} = \frac{i_o}{i_i} \times \frac{i_i}{i_s}$$

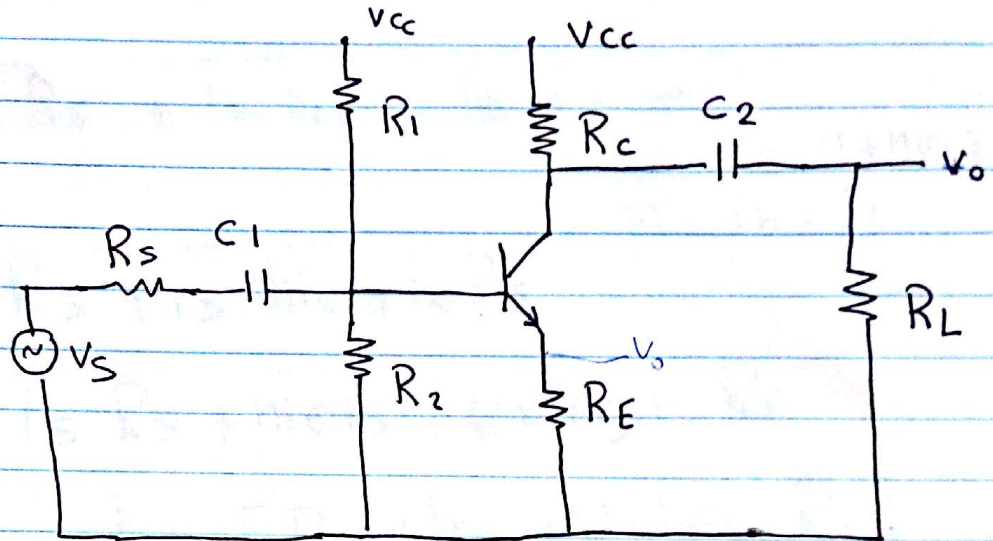
$$\frac{i_i}{i_s} = i_s \times \frac{R_B}{R_B + h_{ie}} \quad \therefore \frac{i_i}{i_s} = \frac{R_B}{R_B + h_{ie}}$$

$$\therefore A_{i_s} = A_i \times \frac{R_B}{R_B + h_{ie}}$$

$$A_p = \frac{P_o}{P_i} = \frac{V_o i_o}{V_{in} i_i} = A_v A_i$$

$$A_{p_s} = A_{v_s} A_{i_s} \quad \text{X}$$

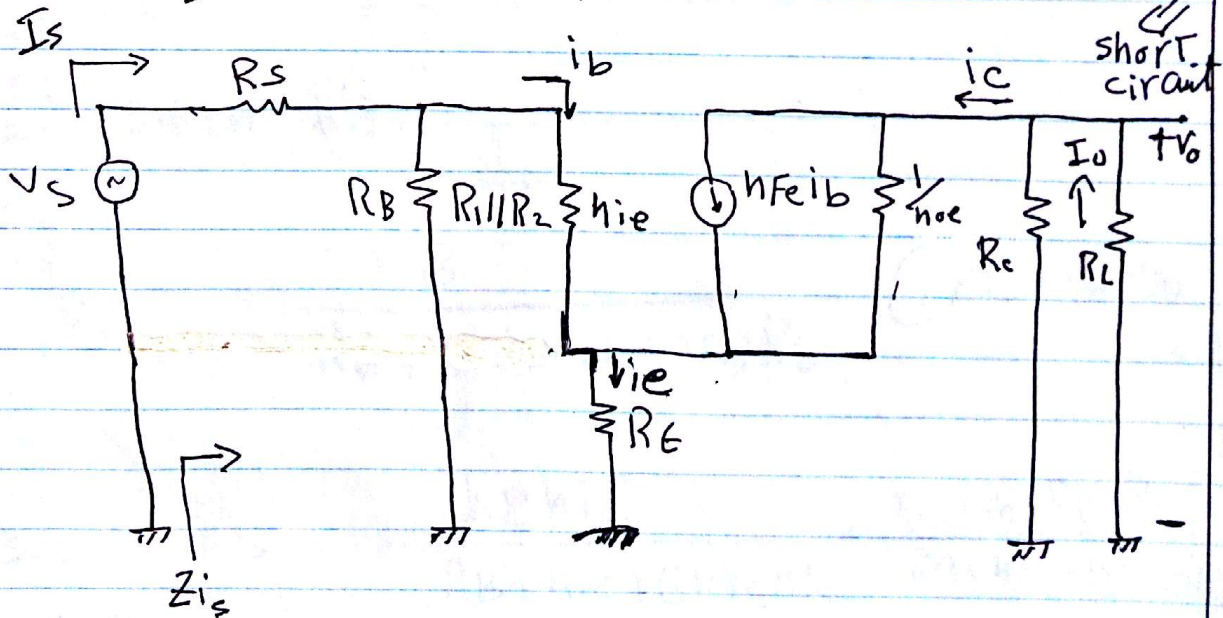
- Find Z_i , Z_o , A_{v_s} , A_{i_s} for the following network



Solution

Steps

1. Put all capacitor in short circuit, also dc source
2. draw the equivalent model



to find Z_{i_s}

$$Z_{i_{ns}} = \frac{V_s}{I_s}$$

apply KVL around the Loop (Remove $R_B = R_1 // R_2$)

$$V_s = i_s R_s + i_b h_{ie} + i_e R_E \rightarrow (1)$$

$$\begin{aligned} i_e &= (1 + h_{fe}) i_b \\ i_b &= i_s \end{aligned}$$

$$V_s = i_s R_s + i_s h_{ie} + i_e R_E$$

$$= i_s R_s + h_{ie} i_s + (1 + h_{fe}) i_s R_E$$

$$\therefore V_s = i_s [R_s + h_{ie} + (1 + h_{fe}) R_E]$$

$$\therefore \frac{V_s}{i_s} = Z_{ins} = [R_s + h_{ie} + (1 + h_{fe}) R_E]$$

when you taken R_B :-

$$i_b = i_s \frac{R_B}{R_B + h_{ie} + (1 + h_{fe}) R_E} \quad \text{(1)}$$

$$\therefore V_s = i_s R_s + i_s \frac{R_B h_{ie}}{R_B + h_{ie} + (1 + h_{fe}) R_E} + \frac{(1 + h_{fe}) R_B R_E i_s}{R_B + h_{ie} + (1 + h_{fe}) R_E}$$

$$= i_s \left[R_s + \frac{R_B h_{ie} + (1 + h_{fe}) R_B R_E}{R_B + h_{ie} + (1 + h_{fe}) R_E} \right]$$

$$Z_{ins} = \frac{V_s}{i_s} = \left[R_s + [R_B // h_{ie} + (1 + h_{fe}) R_E] \right]$$

to calculate Z_o Remove the $\frac{1}{h_{oe}}$

$$Z_o = R_L \parallel R_C$$

→ to calculate A_{v_s} : Remove $\frac{1}{h_{oe}}$

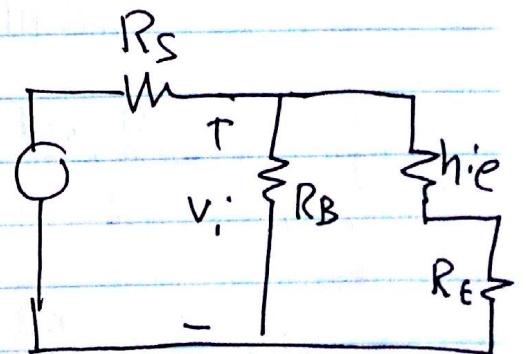
$$\therefore A_{v_s} = \frac{V_o}{V_s} = \frac{V_o}{V_i} * \frac{V_i}{V_s}$$

$$V_o = -h_{fe} I_b Z_o$$

$$V_i = I_b [h_{ie} + (1+h_{fe}) R_E]$$

$$\therefore \frac{V_o}{V_i} = \frac{-h_{fe} Z_o}{h_{ie} + (1+h_{fe}) R_E}$$

$$\frac{V_i}{V_s} = \frac{R_B \parallel [h_{ie} + (1+h_{fe}) R_E]}{[R_B \parallel (h_{ie} + (1+h_{fe}) R_E)] + R_s}$$



$$\therefore A_{v_s} = \frac{-h_{fe} Z_o}{h_{ie} + (1+h_{fe}) R_E} * \frac{R_B \parallel [h_{ie} + (1+h_{fe}) R_E]}{R_s + [R_B \parallel (h_{ie} + (1+h_{fe}) R_E)]}$$

to Find A_{is}

$$A_{is} = \frac{I_o}{I_s} = \frac{I_o}{I_b} \times \frac{I_b}{I_s}$$

$$I_o = \frac{V_o}{R_L}, \quad I_b = \frac{v_i}{h_{ie} + (1+h_{fe})R_E}$$

$$\therefore \frac{I_o}{I_b} = \frac{V_o}{V_{it}} \times \frac{h_{ie} + (1+h_{fe})R_E}{R_L}$$

$$\frac{I_o}{I_b} = \frac{-h_{fe}Z_o}{h_{ie} + (1+h_{fe})R_E} \times \frac{h_{ie} + (1+h_{fe})R_E}{R_L}$$

$$\boxed{\frac{I_o}{I_b} = \frac{-h_{fe}Z_o}{R_L}}$$

$$\therefore I_b = I_s \times \frac{R_B}{R_B + h_{ie} + (1+h_{fe})R_E}$$

$$\frac{I_b}{I_s} = \frac{R_B}{R_B + h_{ie} + (1+h_{fe})R_E}$$

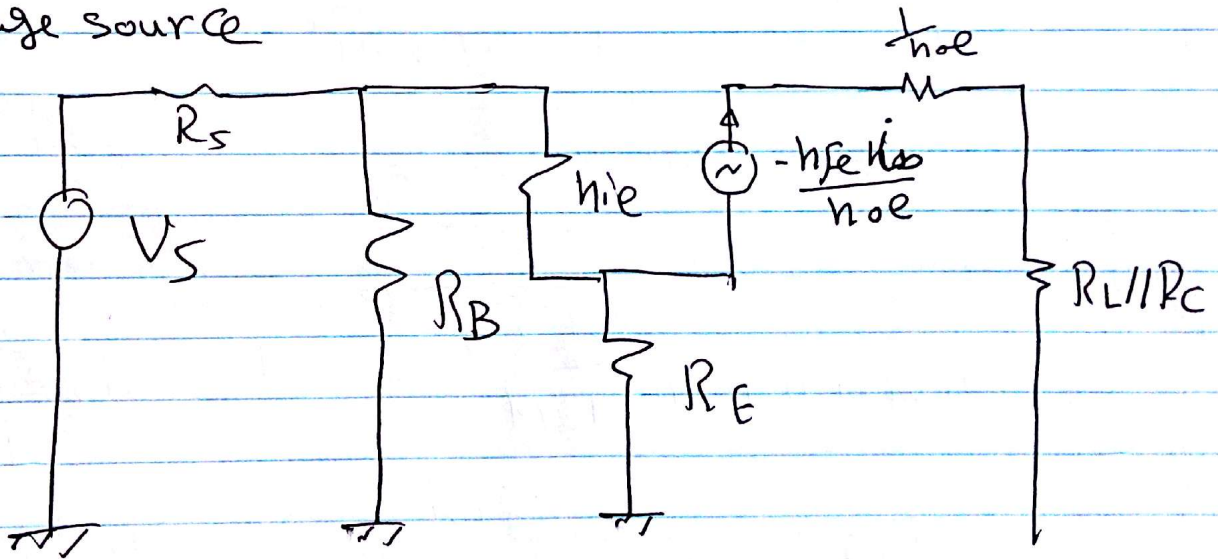
$$\therefore A_{vs} = \frac{-h_{fe}Z_o}{R_L} \times \frac{R_B}{R_B + h_{ie} + (1+h_{fe})R_E}$$

when we taken The effect of $\frac{1}{h_{oe}}$

$$Z_i = R_s + [R_B \parallel (h_{ie} + (1+h_{fe})R_E)]$$

$$Z_o = R_L \parallel R_C \parallel \left[\frac{1}{h_{oe}} + (1+h_{fe})R_E \right]$$

to find A_v :- Convert the current source to voltage source



$$A_v = \frac{V_o}{V_i}$$

$$V_o = \frac{-h_{fe}i_b}{h_{oe}} \times \frac{R_L \parallel R_C}{(R_L \parallel R_C) + (1+h_{fe})R_E + \frac{1}{h_{oe}}}$$

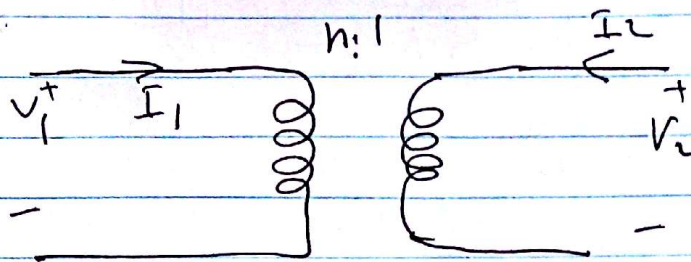
$$V_i = i_b (h_{ie} + (1+h_{fe})R_E)$$

$$\therefore A_v = \frac{-h_{fe}}{h_{oe}} \frac{R_L \parallel R_C}{(R_L \parallel R_C) + (1+h_{fe})R_E + \frac{1}{h_{oe}}} \times \frac{1}{h_{ie} + (1+h_{fe})R_E}$$

$$A_i = \frac{I_o}{I_b} = \frac{1}{\cancel{I_b}} * \frac{-h_{fe} \cancel{I_b} / h_{oe}}{\frac{1}{h_{oe}} + R_E(1+h_{fe}) + R_T}$$

$$A_i = \frac{-h_{fe}/h_{oe}}{\frac{1}{h_{oe}} + R_E(1+h_{fe}) + R_T}$$

② Find ABCD Parameter for the ideal Transformer



Solution

Transformer $\Rightarrow$ conservation of energy

$$V_1 = n V_2 \rightarrow (1)$$

$$\frac{V_1}{V_2} = \frac{n_1}{n_2}$$

$$\frac{I_1}{I_2} = \frac{n_2}{n_1}$$

$$\therefore I_1 = -\frac{1}{n} I_2 \Rightarrow (2)$$

$$\begin{aligned} V_1 &= A V_2 - B I_2 \\ I_1 &= C V_2 - D I_2 \end{aligned} \quad \text{at } (1) \text{ and } (2)$$

$$\therefore a_{11} = A = n, a_{12} = B = 0, a_{21} = C = 0, a_{22} = D = \frac{1}{n}$$

$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} n & 0 \\ 0 & \frac{1}{n} \end{bmatrix} \begin{bmatrix} V_2 \\ -I_2 \end{bmatrix}$$